Volume 3, June 2015

Geomatics in Parks Canada

Parks Canada Parcs Canada

Canada

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Table of Contents Photo: Coastal rain forest trail, Gwaii Haanas National Park Reserve and Haida Heritage Site.
Pg 3 Photo: La Mauricie National Park of Canada, M. Hamel

Geomatics in Parks Canada

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Message from the Chief Executive Officer
of Parks Canada

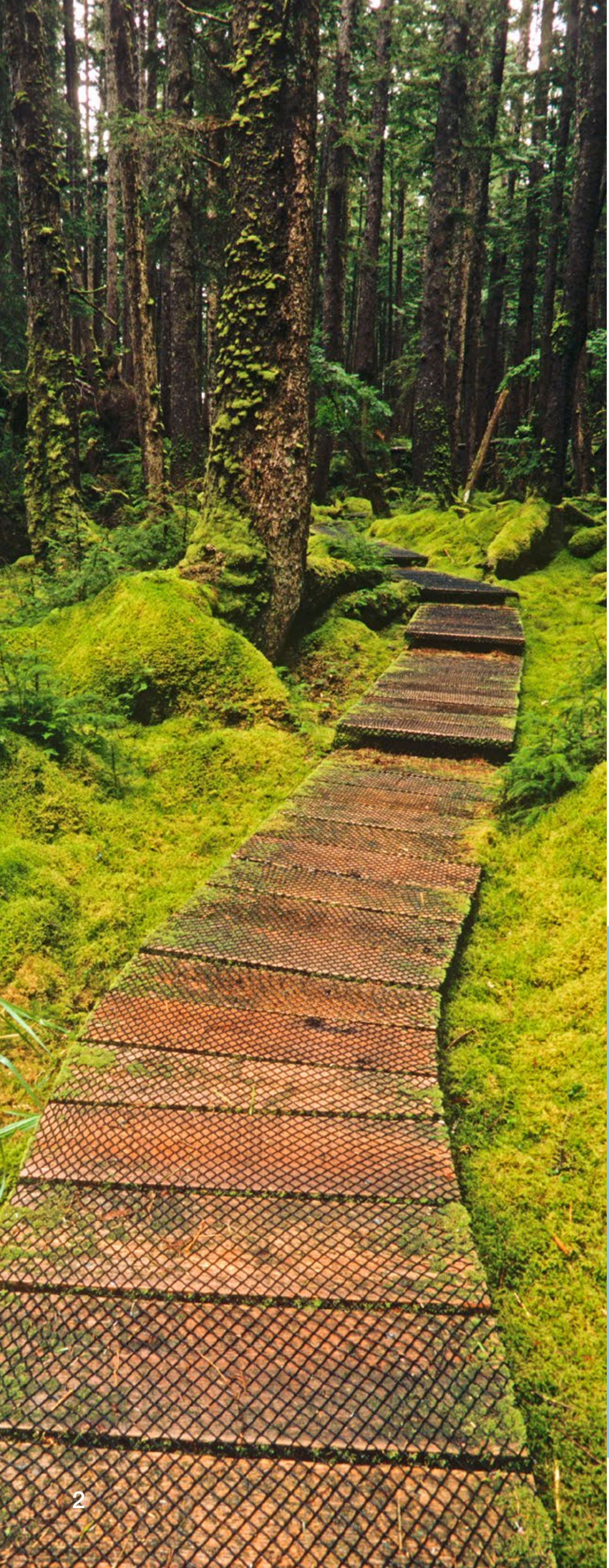
I am pleased to introduce the third volume of *Geomatics in Parks Canada*.

Every day, in National Historic Sites and Parks across the country, I see our team members apply their passion, skills and knowledge to present, protect, and restore the places that represent our natural and cultural heritage. In a vast territory such as ours, some of the challenges we face are bigger than our scope of action. This is why I am proud to see our team partnering at local, national and international scales to accomplish significant advances that no single organization could tackle alone.

Geomatics enables Parks Canada and its partners to work together as one team and realize efficiencies for the benefit of all Canadians. The maps and analyses help everyone agree on what is happening, what was tried in the past and what actions need to be taken. Agency-wide, team members are beginning to use a shared map-base to store corporate knowledge in ways that are accessible to everyone. At a bigger scale, we are participating in a government-wide geomatics initiative which is expected to help partners across public, private and academic sectors collaborate on issues that span the mandates of multiple departments and levels of government.

As we celebrate our accomplishments in this issue of *Geomatics in Parks Canada*, we are reminded that our national parks and national historic sites not only teach Canadians about the past, but also lead the way to a sustainable future.

Alan Latourelle
Chief Executive Officer
Parks Canada Agency



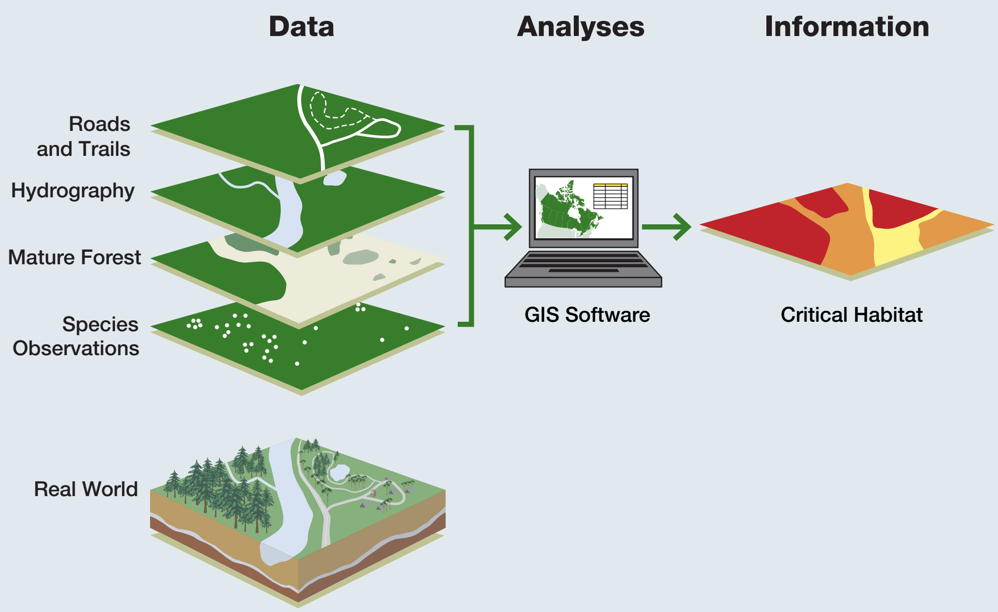
This volume of *Geomatics in Parks Canada* outlines three examples where Geomatics is helping Parks Canada and its partners collaborate in finding solutions that would not be possible for one Agency to take on alone.

Featured Articles

Since the mid 1980s, Parks Canada has invested in Geomatics technology to work more efficiently, to make better decisions, and to work in partnership with our visitors and neighbours.

"Geomatics is the science and technology of gathering, analyzing, interpreting, distributing and using geographic information. Geomatics encompasses a broad range of disciplines that can be brought together to create a detailed but understandable picture of the physical world and our place in it."

Natural Resources Canada



Sources: Parks Canada and ESRI Canada

These disciplines include:

Geographic Information Systems (GIS)
The principal tool of Geomatics. A GIS stores and analyzes geographic data, turning it into geographic "information".

Global Positioning System (GPS)
GPS is a technology that records geographic location through a satellite-based radio navigation system.

Cartography
The art and science of the visual display of the earth and its conditions or properties.

Remote Sensing
The science of deriving information about the earth's land and water areas from images acquired at a distance.

Surveying
The science of measuring distances and angles on the earth so that they can be mapped.

Parks Canada uses geomatics

to obtain or create data and then to transform this data into information. The data can be acquired directly by GPS field-work, radio-telemetry of animals, satellite imagery, marine-based sensors, or aerial photography. It can also be acquired from other agencies, partners, and First Nations. Information about ecological phenomena and human activity is created when data is integrated and knowledge is applied.

Geomatics supports Parks Canada's mandate in the following areas:

- biological inventories and monitoring
- species at risk
- ecological restoration
- visitor studies
- visitor presentations
- search and rescue
- new site development
- boundary delineation
- infrastructure management
- data and information sharing to help partners achieve mutual goals

Parks Canada's Geomatics Infrastructure

The Parks Canada Agency's Geomatics Infrastructure is an enterprise Geographic Information System (GIS) that copies GIS data from across the Agency, turns that data into a standardized set of maps, and distributes those maps to the desktops (and mobile tablets) of staff across the country.

In June 2015, the National Geomatics Coordination Team released a beta version of the *Parks Canada Atlas* (see http://geomat/parksatlas/ if you are connected to the PCA network). Currently, the *Atlas* maps range from a Canada-wide scale down to 1:36,000 (Figure 2). These 1:36,000 maps cover the entire country. For areas in and around national parks, historic sites, waterways, and marine conservation areas, the maps zoom in as close as 1:10,000. Over the next few months, as the Geomatics Infrastructure funnels-in GIS data from across the country, the maps will improve. For areas in and around national parks, the maps will zoom in as close as 1:5,000 (Figure 3). For national historic sites,

Figure 1: A map from the Parks Canada Atlas. Note that the map is tuned to the business requirements of Parks Canada, showing only national parks (green), national historic sites (brown triangles) and national marine conservation areas (blue). Field Unit Boundaries are shown as grey lines. If required, additional data such as weather radar can be added by users.

Figure 2: Example map from the Parks Canada Geomatics Infrastructure. Maps like this one (at 1:36,000 scale) are available for all of Canada. Note how the map is tuned to the business requirements of Parks Canada. Green areas are national park lands, darker blue is national park waters, and pink areas are Indian Reserves. The icons represent a Parks Canada office and campgrounds.

canals, and areas of special interest within national parks, users will be able to zoom the maps in as close as 1:250 (Figure 4).

Unlike most general map applications such as Google Maps or Bing Maps, the Parks Canada Atlas is tuned to the business requirements of Parks Canada. Often what is not shown on a map is as important as what is shown. Reducing the clutter of the maps presents opportunities to customize the map to the issues at hand, and gives more space for users to add their own GIS or GPS data, drawings, or annotations. Users can print maps directly from the Atlas, or paste them into word-processing documents, presentations, and posters.

As Parks Canada staff load these systems with data, they will be storing their corporate knowledge on a shared map-base that is structured and accessible to other staff members.

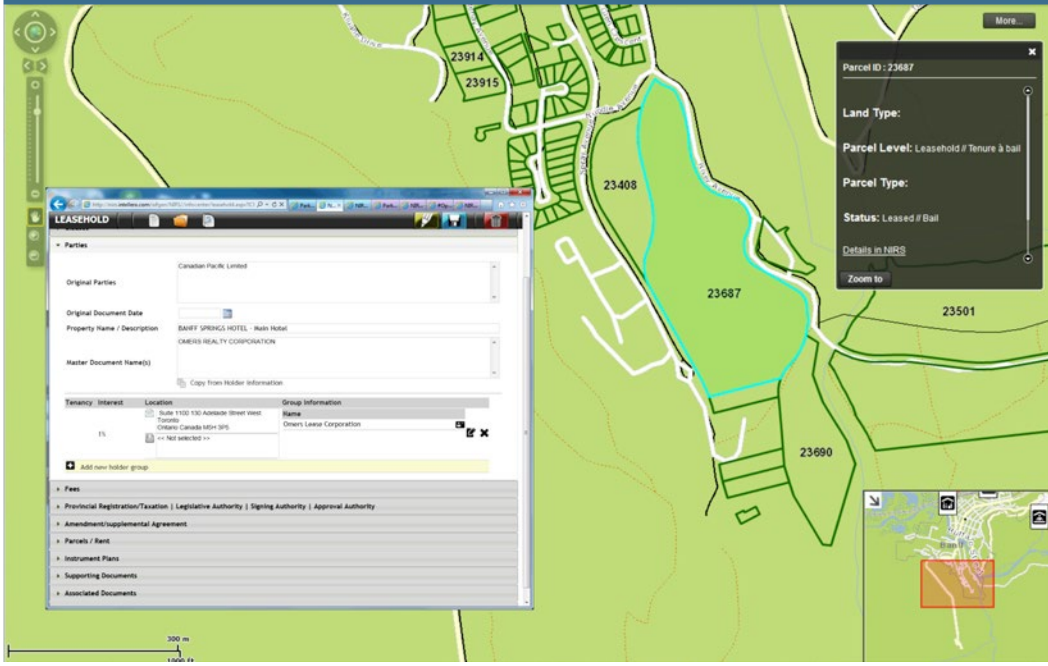
Figure 3: Example of a Parks Canada Geomatics Infrastructure Map at 1:5,000 scale. Maps will be available at this scale for areas in and around national parks by Autumn 2015.

Figure 4: Example of a Geomatics Infrastructure Map at 1:500 scale. By Autumn 2015, maps will be available at 1:250 scale for National Historic Sites, Waterways such as the Rideau Canal, and areas of special interest within National Parks. This map shows the Gulf of Georgia Cannery National Historic Site in Vancouver BC. Green areas denote Parks Canada property, orange indicates area covered by a building. Lines show the floor plan of the Cannery.

Figure 5: The Fairmont Banff Springs Hotel in Banff National Park. The hotel occupies land that is leased from Parks Canada.

The Geomatics Infrastructure also currently provides web-maps to two other Parks Canada applications: the National Integrated Realty System (NIRS), and the national Incident and Event Management (IEM) System.

Figure 6: A map from the National Integrated Realty System (NIRS). The highlighted polygon denotes the footprint associated with a lease document (in this example, part of the Fairmount Banff Springs Hotel). Background maps are provided by the Geomatics Infrastructure.



Virtual Realty

The National Integrated Realty System (NIRS) enables Parks Canada's 50-member Realty team to link their documents (property ownership documents, leases and licences) to parcels of land (Figure 6). The system was built under a contract and is in the process of being installed, configured, and tested. Once fully operational, it is expected to greatly increase the efficiency of most of the Agency workflows that depend on Realty Services. The Realty team's productivity is important to Parks Canada because the Agency is the

"With GIS information populated in NIRS, Realty Services personnel will have fast and accurate visual confirmation of Parks Canada lands, and will be able to respond to enquiries more efficiently and significantly faster than ever before. Our challenge will be to populate the data into NIRS while continuing to meet Agency demands."

Crawford Kilpatrick, Director, Realty and Administrative Services, Parks Canada

Figure 7: This screen-capture from NIRS shows how Realty staff can "rubber-sheet" a survey plan to the base-map so the plan can be more easily found, understood, and related to other map information. A transparency slider allows the user to fade the survey in and out of the foreground.

largest land manager in the federal government, and realty revenues account for approximately 22% of Parks Canada's revenue.

As anyone who has worked with survey documents knows, understanding how a black-and-white survey plan relates to elements on the ground can be a challenge. One interesting feature of NIRS is that it gives Realty users the ability to georeference or "rubber-sheet" survey plans onto the map. They do this by identifying several common points between the survey and the GIS map. The system then stretches the survey so the common points line up, and the survey becomes georeferenced (Figures 7 & 8). A transparency slider allows the user to fade the survey in and out to see how it corresponds to other map information such as buildings or trails. The outcome of this feature is that it reduces the

Figure 8: Close-up view from NIRS showing the survey plan superimposed on the air-photo. This type of view helps Parks Canada managers relate the survey (and therefore the lease agreement) to features on the ground.

time required for staff to find a survey, and once they find it, they can understand it more quickly. The original (non-rubber-sheeted) version of the survey is maintained by the system to preserve the integrity of the survey.

Incident Mapping

The Incident and Event Management System (IEM) was the first national application to use Geomatics Infrastructure maps. IEM helps National Park Wardens document and manage law enforcement incidents and planned events. It is a mobile system that uses tablet computers that are carried by wardens or mounted in their vehicles. The application, which was developed by the Parks Canada Information Systems Team, remains fully functional when the user is disconnected from the PCA network or cellular networks (e.g., when a Warden is in the backcountry). Wardens who are disconnected continue to use IEM to view maps, see their locations, query the system and input data. When they return to the office, IEM synchronizes the changes with the national system. IEM is designed to help the law enforcement team be more effective (e.g., have better structured information for court cases) and work more efficiently (spending less time doing paperwork and more time out in field).

"Situational awareness is an important aspect of natural resource law enforcement and the guiding principle behind IEM. We decided early on to follow industry standards for incident management systems that includes the ability to georeference incident locations on a map-based interface."

John McKenzie, Manager, Strategic Programs, Law Enforcement Branch

Figure 9: The Incident and Event Management (IEM) System is a map-based system that runs on mobile tablets that are carried by National Park Wardens or mounted in their vehicles. IEM continues to function while disconnected from the PCA network and cellular signals. Upon returning to the office, the system synchronizes any changes with the central database. (Simulated screen content for illustrative purposes).

Map Once, Use Many Times

The next two years will see more national applications using the Infrastructure. These include:

National Systems that are Operational and Near-Operational:

- Parks Canada Atlas
- National Integrated Realty System (NIRS)
- Incident and Event System (IEM)
- Parks Canada GIS layers for the *Government of Canada Open Data Portal*

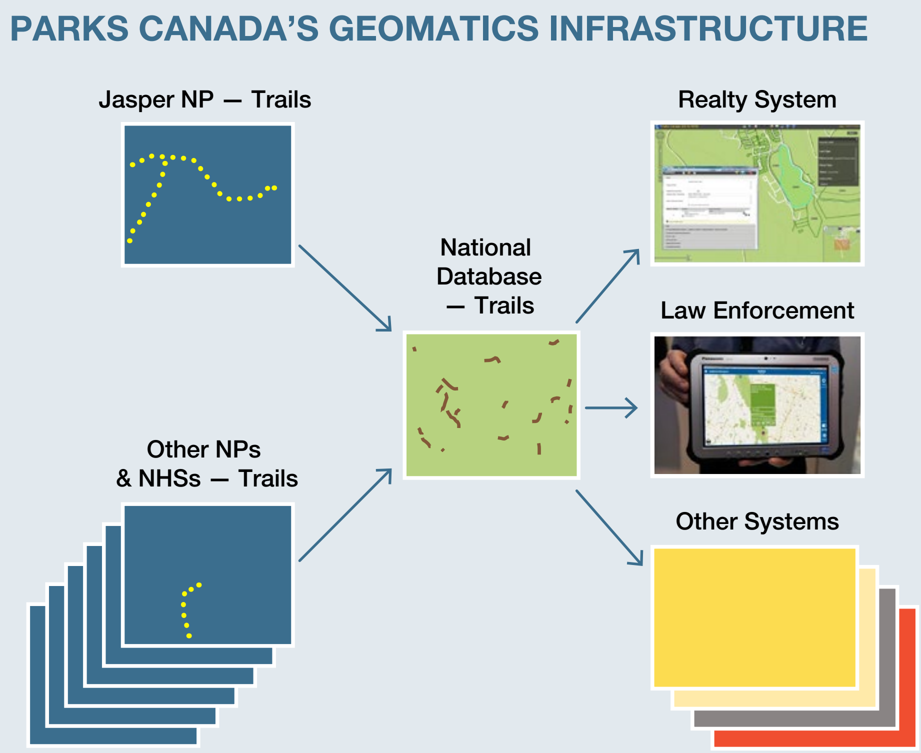
National Systems in Development:

- Maximo (the national asset management system)
- A cultural resource management information system
- A new National Dispatch system

Each of these systems will use the same map data. This means that edits will be made by the authoritative data steward at the park level, then the updated data will be passed to all consuming systems. In other words, the steward will not have to update the data in each and every system. Figure 10 shows a conceptual model for the principle of "edit once, use many times".

As Parks Canada staff load these systems with data, they will be storing their corporate knowledge on a shared map-base that is structured and accessible to other staff members. An example where this investment of time would pay off is in a scenario of a backhoe operator preparing to replace a culvert. He might check the map for buried cables, or sewage lines, and be surprised to see nearby fish habitat that needs protection from sediments. The asset system may also show him a water valve that needs replacing while the hole is already open. In this example, simply by looking at the map,

Figure 10: An overview showing data flows of the Geomatics Infrastructure. Data stewards at national parks across Canada maintain GIS data such as trails (pictured). The Infrastructure copies the data and distributes it to several consuming applications.



"As a result of the Agency's IMST (Information Management, Systems, & Technology) Planning, expect to see more and more integration of our information systems. This will be most evident in systems that share geographic information (Realty, Asset Management, Ecological, and Cultural Resource Systems, to name just a few). All of this is in support of better decision making. Also, we are now in a better position to share geographic information (both ways) with other departments, other levels of government and with our partners. Stay tuned for more… this is a really exciting time for Geomatics."

Greg Thompson, Chief Information Officer, Parks Canada the backhoe operator becomes the recipient of the corporate knowledge of several staff members. The concept of placing corporate knowledge on a common map-base fits well with Parks Canada's corporate direction of having *One Team, One Vision, and One Voice.*

Part of an Even Bigger Picture

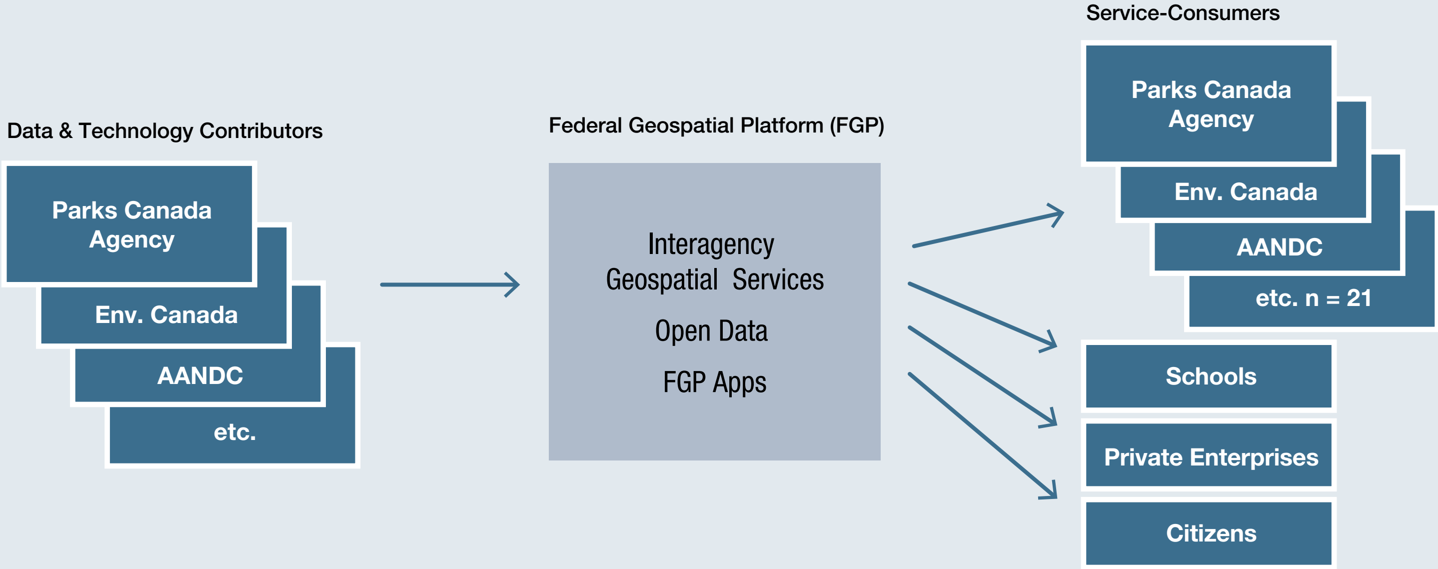
In May of 2014, the Treasury Board of Canada approved a project called the Federal Geospatial Platform (FGP). The FGP will be a collaborative online environment that will link together 21 federal government departments and agencies that use geomatics. It will make it easier for everyone to produce maps that require geospatial data from multiple departments. Examples of this requirement include maps for emergency response, environmental assessment, or tourism. The FGP will also provide a central location where the public can find geospatial data that is offered under Canada's Open Government initiatives. Figure 12 provides an overview of data and information flows between contributing departments and consumers of FGP services and data.

The infrastructures of the FGP and Parks Canada were planned to work in concert with each other. As the edits to geospatial data from the national parks are copied by the Parks Canada Geomatics Infrastructure, they will be automatically passed along to the FGP. Updates to the location of the West Coast Trail, for example, could be reflected in private enterprise applications such as Google Maps within hours.

At a technical level, both the Parks Canada Geomatics Infrastructure and the FGP will reside in the same "cloud" (network of data centres) that is managed by Shared Services Canada. It is anticipated that over the next few years, economies of scale will become available, and the two infrastructures will become even more integrated.

Figure 11: Parks Canada Team Members replace a culvert at Pacific Rim National Park Reserve. Geomatics Infrastructure maps will enable staff to share their corporate knowledge to plan for risks to employee safety (e.g. by identifying buried cables), built infrastructure, ecological integrity, cultural resources and Aboriginal values. (Photos: J. McIndoe, Parks Canada)

Figure 12: Overview of the data and information flows between contributing federal departments and agencies and consumers of FGP services and data. FGP services will include a visualization tool, multi-departmental applications, and the Open Data Portal for geospatial data.



The results are expected to be improved map-system performance, lower costs, and access to information by greater numbers of clients from inside and outside of the Public Service. More significantly, the two infrastructures will help integrate the work of Parks Canada with other departments, the private sector, and private citizens. This will help transform Parks Canada into a more efficient, open, and knowledge-based organization.

> "The Federal Geospatial Platform is an excellent example of a transformative initiative that will help move the Public Service towards a modern, tech-enabled organization that manages its geospatial assets more effectively to support policy priorities, such as the conservation of our National Parks."

David Harper, Director, Federal Geospatial Platform Initiative, Earth Sciences Sector, Natural Resources Canada

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Restoring Natural Ecosystem Processes to the Peace Athabasca Delta

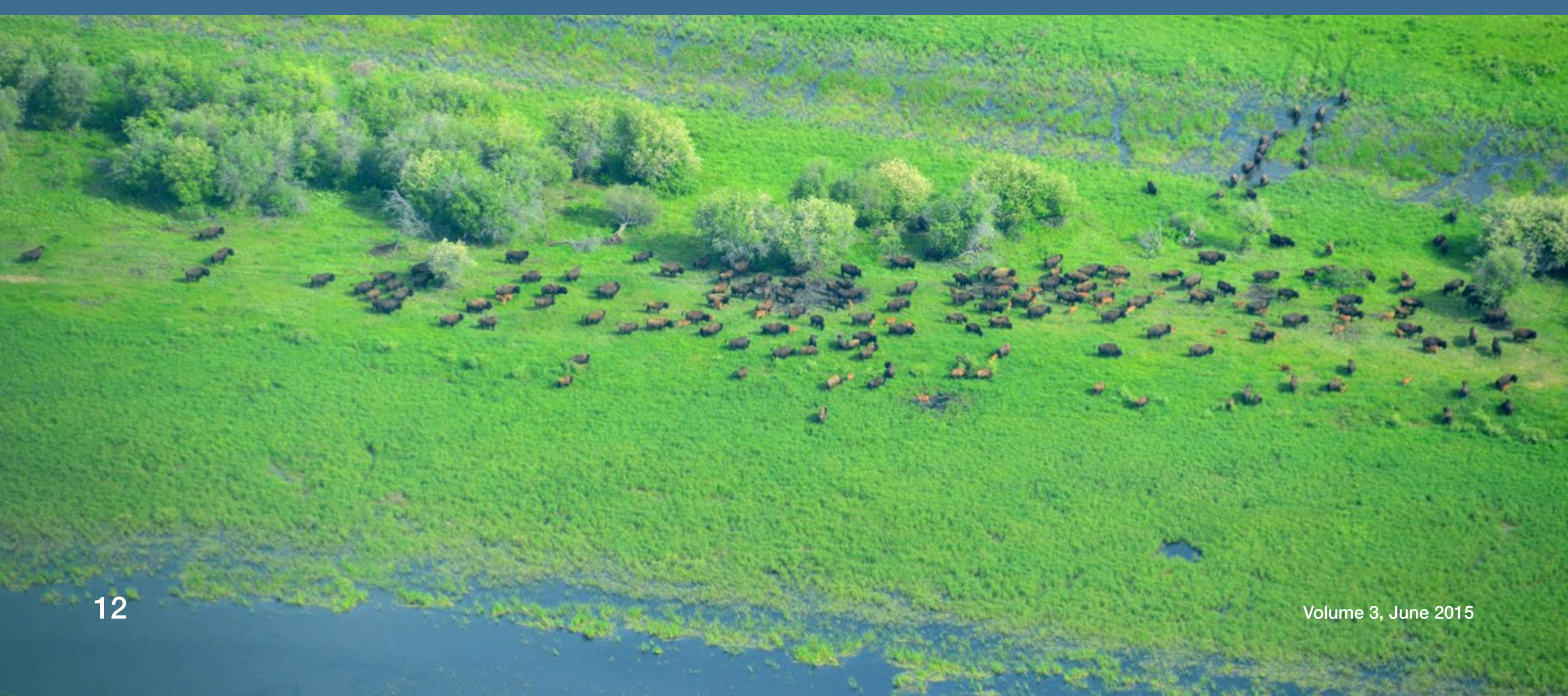
in Wood Buffalo National Park

The Peace Athabasca Delta (PAD) is one of the largest freshwater deltas in the world. It has been designated as a Ramsar Wetland of International Importance because of the habitat it provides for birds that migrate along several major North American flyways to their breeding grounds in the north. The vast sedge meadows of the delta offer habitat crucial to the world's largest free-roaming herd of wood bison and the wolves that prey on them. The PAD is an important homeland for First Nations and Métis people who have hunted, trapped, and fished there for generations.

Most of the PAD is contained within Wood Buffalo National Park, which itself is a designated UNESCO World Heritage Site. Along with the mandate to protect the park for future generations and to foster enjoyment and understanding of this incredible area, Parks Canada is responsible for protecting Species at Risk found there. In addition, the Agency must

Figure 1: Map showing the location of the Peace-Athabasca Delta in Wood Buffalo National Park, as well as upstream watersheds, including major dams on the Peace River (Source: Parks Canada).

Figure 2: Aerial view of a wet sedge meadow in the Peace Athabasca Delta with a herd of wood bison. The light-brown animals are calves. (Photo: J. McKinnon / Parks Canada)



ensure that its efforts respect Canada's commitments to Aboriginal people. Many of those commitments were established pursuant to Treaty 8, long before the park received its heritage designation.

Figure 3a: Egg Lake in 1994, 20 years after the most recent flood event of 1974. Egg Lake changed from a wetland to a meadow in the absence of flood water inputs. Note the encroaching willow growth with the dry conditions, in the left foreground and in the background. (Photo: Parks Canada)

Figure 3b: Egg Lake in 1998, two years after a flood event (1996–1997) which was augmented by BC Hydro after discussions with Parks Canada. Egg Lake is once again a wetland. Note that flooding has killed the encroaching willows, in the foreground and background. (Photo: Parks Canada).

A Flood-dependent Ecosystem

In the words of a Mikisew Cree First Nation elder, "Water is boss." Periodic flooding from the Peace and Athabasca Rivers is required to maintain the delta's wetland habitat, thus preserving the biodiversity needed to support the wood bison (Figure 2), migratory birds, and the connection between Aboriginal people and the land.

Floods help preserve the diverse patchwork of habitats required by many species. Figure 3a shows a flood-dependent lake that had not flooded in 20 years. Dense vegetation such as grass and willow has taken over the area. The photograph in Figure 3b was taken from the same vantage point two years later following a flood. The encroaching vegetation (such as the willow) has died back, and the wet, open habitat has been restored.

Figure 4: A muskrat (*Ondatra zibethicus*), a common resident of the Peace Athabasca Delta and a cultural keystone species that depends on periodic flooding to maintain its wetland habitat. (Photo: Parks Canada)

An example of wildlife that use flood-dependent areas is the muskrat (*Ondatra zibethicus*) (Figure 4). Aboriginal people around Fort Chipewyan have referred to the muskrat as a "cultural keystone species" because it is highly important to their way of life — providing First Nations and Métis people with traditional food, fur and clothing, and income. Hunting and trapping muskrat has been an important part of the connection between the land and Aboriginal people of the area for hundreds of years.

"Water is Boss". Periodic flooding is essential to the ecological health of the Peace Athabasca Delta (PAD).

Figure 5: Aerial view of ice jam on the Peace River. Dark areas are rough ice, with floating woody debris carried from flooded banks. (Photo: S. Macmillan / Parks Canada)

Flood Mechanics

Floods in the PAD occur when several necessary circumstances come together. The first requirement is winter conditions that produce thick ice, which is sufficient for creating ice jams. The second is the presence of a good snow-pack in the watershed, which ensures the ice remains intact for a longer period of time. When these conditions combine with a fast spring melt, the river experiences a strong "freshet" (an increased flow of water) that lifts and breaks the ice, then carries it downstream where it jams against intact ice cover. Once an ice jam is established, a small increase in flow can cause a dramatic rise in water levels upstream of the jam before it disintegrates (Figure 5). This can lead to a flood event with major effects on the delta's ecosystem.

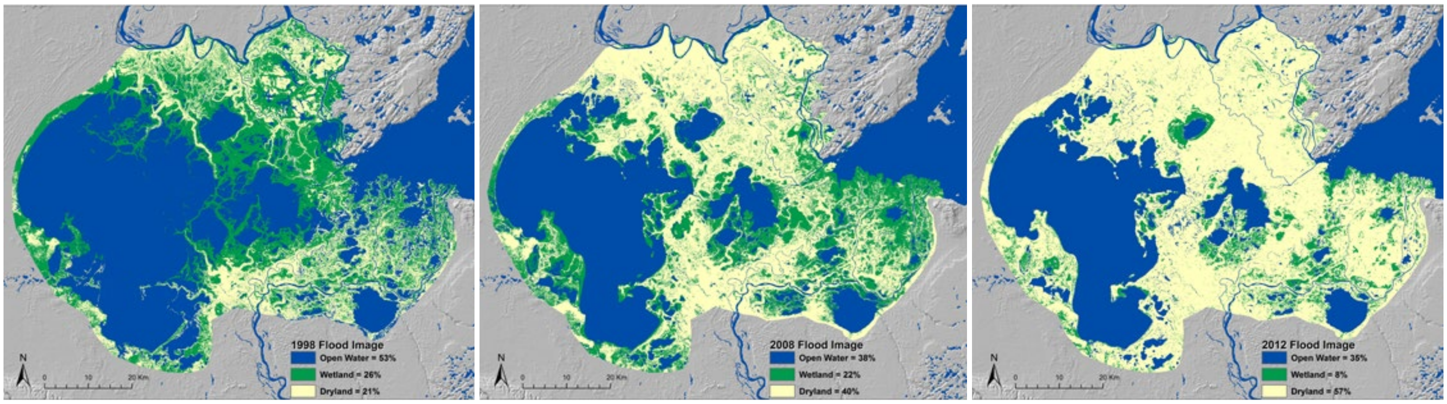
A Drying Trend

Over the last 45 years, the PAD has experienced a drying trend. Floods that normally replenish the wetlands are happening less frequently. This reduced number of floods is due to the cumulative effects of climate change, upstream water use, and flow regulation of the Peace River. There are two upstream dams (the W.A.C. Bennett Dam and the Peace Canyon Dam) that regulate the flow of the Peace River, and a third dam, Site C, is under development (Figure 1).

Modifications to the Peace Athabasca drainage system are already causing changes in delta ecology. For example, losses of wetlands can be linked to reductions in the abundance of muskrat. Local people are reporting that changing plant communities, water levels, and patterns of use by wildlife have affected their traditional use of the area. To many, this means a loss of their cultural connection with the land.

Over the last 45 years, the Peace Athabasca Delta has experienced fewer floods due to climate change, water use, and flow regulation.

Figure 6: Extent of flooding in the Peace Athabasca Delta based on RADARSAT images. Note the dramatic difference between a year immediately following a flood (left image; 1998) and a year with no extensive spring flooding for over a decade (right image; 2012). (Source: Parks Canada / J. Töyrä, Environment Canada)



The Solution

Many of the changes that affect the PAD originate far outside of the park, and some can be mitigated — or perhaps even reversed. An example of partners coming together to take action was in 1996 when BC Hydro, in partnership with Alberta, Environment Canada, Parks Canada, and local Aboriginal groups saw an opportunity to augment flooding of the delta. Parks Canada monitored ice conditions in the PAD and conferred with local Aboriginal groups about the possibility of flooding. When conditions were ideal, Parks recommended that BC Hydro increase flow through the W.A.C. Bennett dam. This timely action contributed to the flood event shown in Figure 3b and first of the three maps shown in Figure 6 (the first flood in 20 years).

Figure 7: Parks Canada staff discuss their flight plan with a helicopter pilot. GIS is used for planning trips to specific locations within the Delta in order to verify interpretations of satellite imagery and map the extent of flooding on the landscape. (Photo: J. McKinnon / Parks Canada)

The success of the exercise was documented by Environment Canada and the Government of Alberta through their long-term monitoring of the delta's water levels.

As the lead agency responsible for the preservation of the PAD and the Species at Risk that depend on it, Parks Canada has been working with stakeholders to understand what is happening in the PAD, what is at risk, and what can be done to maintain or restore the delta's ecological integrity and cultural values. The initiative is divided into three phases:

1. Quantify the effects of flooding

Parks Canada has been working with Environment Canada's National Water Research Institute to annually monitor the extent of surface water and associated vegetation. Satellite images (Landsat, SPOT, and RADARSAT) are analyzed each year, and GIS is then used to track the ecological changes over time. An example of this type of analysis is shown in Figure 6.

"Ground-truthing" field work is done by Parks Canada to ensure that the analyses are correct and defensible. GIS helps plan the field work (efficient planning reduces costs for resources, such as helicopters), and GPS is used to navigate to sites and collect observations. The field data are later analyzed in the

GIS and used to improve the analysis of change and to estimate its accuracy.

In addition to the work described above, Parks Canada also documents changes in abundance of muskrat and wood bison, and diversity of vegetation, amphibians, and marsh birds through its ongoing Ecological Integrity Monitoring and Species at Risk programs. GIS, GPS, and Remote Sensing each contribute to the process of planning, carrying out, and presenting results of these ongoing efforts.

The wolves of Wood Buffalo National Park such the cub pictured here prey on many of the species that depend on periodic flooding of the PAD.

2. Build consensus among stakeholders

In 2014, Parks Canada presented its analysis to the Site C Joint Review Panel as it conducted an environmental review of Site C, a new BC Hydro hydroelectric project on the Peace River. At the hearings, BC Hydro offered to consider proposals to augment flows at strategic times in order to help re-establish spring floods to the PAD. In the Panel's final report, BC Hydro, Parks Canada, the Government of Alberta, and others (including Aboriginal groups) were encouraged to work together to continue investigating options to preserve the PAD.

Parks Canada and its partners continue to meet regularly to share and update their understanding of what is happening in the PAD. In February 2015, the Peace-Athabasca Delta Ecological Monitoring Program (a group of delta stakeholders brought together by Parks Canada) reaffirmed the importance of the PAD and of finding a shared solution to help preserve it.

3. Model the potential effects of various management actions on the delta

In addition to documenting what is *currently* happening, Parks Canada is working with some partners to model what *would likely happen* following various management actions on the Delta. These models become more precise as data such as LIDAR become more available. The ability to model these scenarios is crucial to developing effective strategies to restore and maintain the ecological integrity of the delta.

Results Today

The drying trend continues to present a serious threat to the ecology of the Peace Athabasca Delta, and regional stakeholders and decision-makers have agreed that management actions are required to protect the PAD. The augmentation of the 1996–1997 flood brought about by cooperation among BC Hydro, Environment Canada, Parks Canada, and local Aboriginal groups shows that effective collaborative action is indeed possible. The recommendations of the Site C Joint Review Panel, and the willingness of BC Hydro to continue examining the practicality of augmenting delta flooding, offer hope that restoration and maintenance of the ecological integrity of the PAD is possible.

The maps and analyses provided by the geomatics program at Wood Buffalo National Park and its partner organizations are crucial tools that are required to support the development of these collaborative solutions.

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Environment Canada's National Water Research Institute (NWRI):
http://www.ec.gc.ca/inre-nwri/

Peace-Athabasca Delta Ecological Monitoring Program (PADEMP):
http://pademp.com/

Turning the Tide on Ecosystem Decline
at Kejimkujik Seaside

Figure 1: Map showing the Kejimkujik Seaside. (Map: S. O'Grady, Parks Canada)

Kejimkujik National Park and National Historic Site in Nova Scotia was established to protect and present the Atlantic Coastal Uplands Natural Region. In 1985, Kejimkujik National Park Seaside (Kejimkujik Seaside) was added to the Park. It features spectacular white sand beaches with dunes, headlands, tidal flats, wetlands, and salt marshes. Two highly productive estuary lagoons contain rich biodiversity that depends on a narrow interface between fresh and salt-water ecosystems.

Coastal ecosystems all over the world are in decline, and, until recently, the lagoons of the Kejimkujik Seaside have been no exception. Invasive species such as the European green crab (*Carcinas maenas*) have had devastating effects, displacing or consuming native species and in extreme cases, altering natural processes.

With the help of partner organizations (see Table 1), Parks Canada has had success in restoring its coastal ecosystem at Kejimkujik Seaside. Geomatics played an essential role, helping to understand the problem, plan restoration work, and quantify results.

> "Nowhere else in the national parks of Atlantic Canada is there such a richness of marine life in the clear shallow waters, typical of much deeper, off-shore water."
>
> ***Interpretive Storyline for the Seaside Adjunct for Kejimkujik National Park, Burzynski 1992***

Table 1: List of partners involved in the project

- Parks Canada
- Fisheries and Oceans Canada
- Nova Scotia Fisheries and Aquaculture
- Dalhousie University
- Acadia University
- Applied Geomatics Research Group, COGS, NSCC
- St. Francis Xavier University
- McMaster University
- Cégep de Sherbrooke
- Friends of Port Mouton Bay
- Harrison Lewis Marine Centre
- Port Joli Basin Conservation Society
- Native Council of Nova Scotia
- Harbour Authority of Port Mouton
- Local communities and volunteer fishers

Figure 2: St. Catherine's Estuary, July 2014. (Photo: Parks Canada / Vision Air Ltd. / L. Wagg)

The Heart of the Ecosystem: Eelgrass and Soft-shell Clams

Two important species to the Kejimkujik Seaside coastal ecosystem are eelgrass (*Zostera marina*) and soft-shell clams (*Mya arenaria*). Like trees in a forest, eelgrass provides structure, a food base (primary production), nutrient cycling, and water filtering for the ecosystem. Eelgrass also dissipates the energy of waves, protecting sensitive shorelines (such as saltmarsh) from erosion. The soft-shell clam is a vital food source for native species and migrating shorebirds to restore their energy reserves.

Figure 3: Parks Canada diver monitoring eelgrass. Eelgrass is the "forest" of estuarine ecosystems. (Photo: O. Woods, Parks Canada)

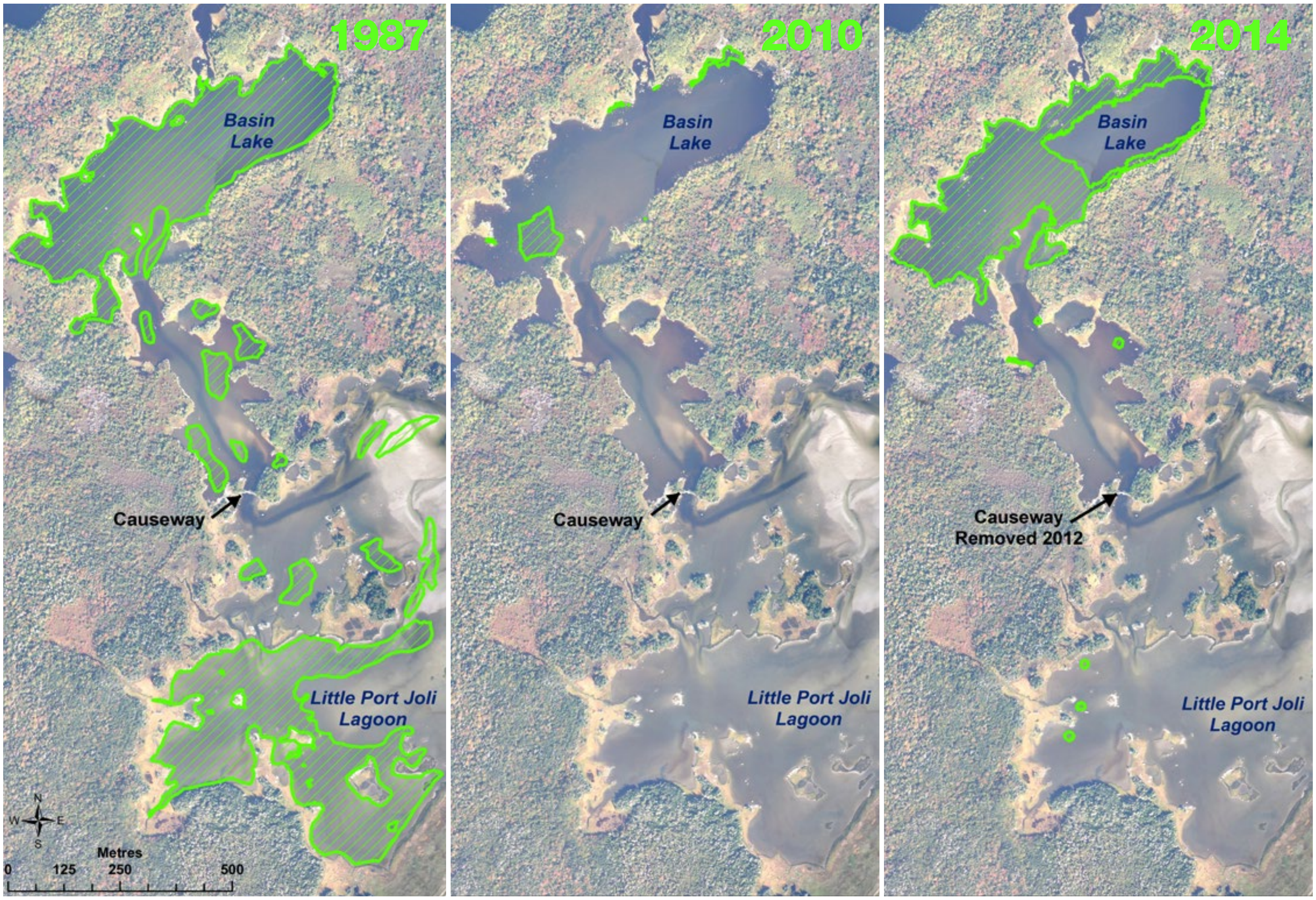
Ecosystem Wrecking Ball — The European Green Crab

Green crabs first arrived in North America early in the 1800s, but it was not until the 1980s that a new clade (race) from the Faroe Islands (southeast of Iceland) arrived in Nova Scotia. This highly cold-tolerant race has invaded the estuaries of Kejimkujik Seaside. As they dig their burrows and forage for food, the crabs shred and cut eelgrass shoots. The impact of this invasion has been so strong that by 2010, eelgrass at Kejimkujik Seaside had declined by more than 98%. As the eelgrass disappeared, so did other native organisms and commercial marine species that depend on it.

The ecological impacts of the crab are not limited to eelgrass. A single green crab can consume as many as 40 soft-shell clams in one day. Since 2007, Parks Canada's monitoring programs indicated that younger-age classes of soft-shell clams are largely absent, which could lead to a population collapse and affect the food supply for migratory birds.

Figure 4: A pair of European Green Crabs (*Carcinas maenas*). A new clade from southeast of Iceland has been causing massive changes to the estuarine ecosystems of eastern North America. (Photo: O. Woods, Parks Canada)

Figure 5: Eelgrass distribution in the Little Port Joli Estuary. This GIS map shows eelgrass distribution (light green hatch pattern) in the western half of the Little Port Joli Estuary in 1987 (before the green crab invasion), 2010 (at the beginning of the recovery project, and in 2014 following five years of green crab removal and eelgrass propagation by Parks Canada and partners. The smaller spots of eelgrass in the southern half of the map are the result of transplant efforts. In 2012, a causeway was removed to re-establish natural patterns of tidal flow. (Map: S. O'Grady, Parks Canada)



Parks Canada also suspected that in the Little Port Joli Estuary, the problem had been made worse by an old causeway and bridge that restricted the tidal flow from a 40-metre-wide channel to 6 metres.

> "We are finding nothing but green crabs in our eel traps. Something needs to be done or there'll be nothing left in the ocean…"
>
> *Russell Nickerson, local fisherman*

Figure 6: Before and after photos showing the removal of a causeway that was restricting natural tidal flushing processes the Little Port Joli Estuary. The causeway was removed in 2012. (Photo: C. McCarthy, D. Pouliot, Parks Canada)

Verification Before Action

It was suspected that the changes to the ecosystem were being caused primarily by the invasive green crab. However, ecosystems are complex, and often their changes are due to more than one factor. Parks Canada and its partners wanted to verify their assumptions before taking action on the ground. They conducted a significant ecosystem monitoring program that measured (among other things) sand migration, vegetation communities, salt marsh erosion, and water quality. The results helped dispel questions of whether declines in eelgrass and soft-shell clams were due to other factors such as water quality or sediment movement.

Estuary Therapy

Even though successful marine restoration projects are rare, Parks Canada and its partners created a project to prescribe some *estuary therapy*. It was decided to treat only one of the estuaries, and leave the other as a control to better understand whether or not the restoration work was effective. Also, it was thought that the quantitative results showing treated versus untreated sites would help others working on similar problems in estuaries around the world.

Restoration of Little Port Joli Estuary involves four main actions:

- Removing green crabs, monitoring effects, and comparing results with the control estuary (St. Catherine's River Estuary);
- Transplanting eelgrass and soft-shell clams to the restored areas, and monitoring effects;
- Restoring the natural tidal flushing regime by removing the bridge and causeway, rehabilitating the former borrow pits with this overburden, and monitoring effects on water quality and hydrological flow; and
- Supporting partners researching potential uses for green crabs to create economic demand.

Figure 7: Parks Canada employee W. Richards and volunteer C. Durovitch pulling green crab traps. (Photo: K. Durovitch, Parks Canada Volunteer)

Figure 8: Eelgrass transplants ready for deployment. Part of the ecosystem recovery project involved re-planting eelgrass in areas where it had been found prior to the invasion of the European green crab. (Photo: J. Reid, Parks Canada Volunteer)

Figure 9: A European green crab eating a blue mussel. Bivalves are a favourite food and a single crab can eat up to 40 clams in one day. (Photo: O. Woods, Parks Canada)

How Geomatics Helped

Geomatics at Kejimkujik Seaside has been involved in every step of the restoration of the Little Port Joli Estuary:

- GIS was used in several studies and monitoring programs to help verify Parks Canada's understanding of the problem. This included analyzing the rates of dune movement and vegetation change and modeling coastal flooding due to surge tides and sea-level rise.
- GIS analyzed sediments, habitats, and hydrological parameters to find the best places to trap green crab.
- GPS units were used by conservation technicians as they swam the edges of eelgrass beds in both estuaries to accurately map eelgrass distribution.
- Analyses of green crab trap yields and other ecological parameters helped determine the best places to transplant eelgrass. This project marked the first time that eelgrass transplants were successful in Atlantic Canada.
- GIS provided the sample design to monitor soft-shell clam populations and and assess the effectiveness of the green crab removal.
- Air photo interpretation identified historic borrow-pits that were originally used to construct the causeway. Those pits were refilled with the original material.

"Geomatics played a key role in this project in terms of planning, executing and evaluating success. Aerial photos dating back to 1929 allowed us to define normal rates of change, compare them to the change that was occurring and then set recovery objectives. GIS was essential to our crab trapping strategies by helping us to focus our efforts on the high priority areas. It also helped us develop our recovery strategies for eelgrass and soft-shell clams."

Chris McCarthy, Ecologist Team Leader, Parks Canada

- GIS helped define the shoreline restoration work that needed to be done after the causeways had been removed.

An Ecosystem Recovers

- Since 2010, over 1.5 million green crabs have been removed from the Little Port Joli Estuary. Ongoing monitoring indicates that green crab numbers have been reduced to below the ecosystem recovery threshold.
- Eelgrass decline has been reversed at Little Port Joli Estuary. In the last four years, eelgrass has increased in area by more than 10 times, to 34% of its original distribution (see Figure 5). Eelgrass has not re-established in the St. Catherine's River Estuary (the untreated control) where green crab densities remain high.
- The abundance of native biodiversity (shorebirds, fish, lobster, rock crab, etc.) is increasing at Little Port Joli Estuary where green crabs are under control. These native species are still in decline in the untreated St Catherine's River Estuary.
- Fisheries and Oceans Canada has created a licenced commercial fishery for green crab in southwestern Nova Scotia, based on the research conducted by Parks Canada and its partners. The crabs are being used for lobster bait, and industry continues to explore other uses such as human consumption, glucosamine, fertilizer, and biopolymer products.
- The causeway and bridge have been fully removed, re-establishing the natural tidal flushing process to the upper estuary.

Figure 10: Parks Canada Geomatics Specialist Sally O'Grady surveys the movement of sand dunes as part of a larger Ecological Integrity Monitoring Program at the Kejimkujik Seaside. (Photo: C. McCarthy, Parks Canada)

Propagating Success

Now that the invasive crab numbers have been reduced in Little Port Joli Estuary, restoration work has entered a maintenance phase. GIS will continue to play a key role in tracking restoration efforts with eelgrass and soft-shell clams. At St. Catherine's River Estuary, restoration operations will commence this year with help from *Action on the Ground* funding in the hopes of repeating the success seen in the other estuary.

Parks Canada and its partners have reversed the decline of one of its major ecosystems at Kejimkujik Seaside in keeping with Canada's *National Conservation Plan*. This project marks the first time that invasive green crab has been controlled in an eastern North American estuary. Best practices and lessons learned by Parks Canada and its partners are being shared with other organizations as they work to restore other estuaries outside the national park. The success of the restoration work will help ensure that present and future generations of Canadians are able to enjoy and learn about these spectacular ecosystems.

"The whole system was in decline. By controlling green crab and removing the causeway, everything is coming back: eelgrass, fish, lobster, clams and shorebirds. It's been quite a success."

Chris McCarthy, Ecologist Team Leader, Parks Canada

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